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Lighting up the Blackout: Technology Upgrades to America's Electrical System

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Madam Chairwoman, Congresspersons, Ladies & Gentlemen:

My name is Tom Casten and I am the Chairman and CEO of Private Power in Oak Brook, Illinois. I appreciate the opportunity to present my views on preventing blackouts while saving money and reducing pollution. We have the technology, but block its use because of a now obsolete worldview. We have heard much about an "industry consensus vision" for a smart, self-healing grid. This view focuses on modernizing the grid, but falls short on modernizing the worldview and leads to more wires we don't need. Applying three (3) simple principals will optimize the power system. The principals are:

- Build local power
- Build smaller
- Recycle waste energy.

Blackouts blackouts everywhere

On August 14th, around 2:00 PM, a 31-year-old, 650 megawatt Ohio power station failed. Transmission controllers struggled to route power from remote plants, overloading transmission lines. At 4:06, a 1200-megawatt transmission line melted, starting a failure cascade. Lacking local generation, system operators could not maintain voltage and five nuclear plants tripped, forcing power to flow from more remote plants and overloaded regional lines. By 4:16 PM, the northeastern US and Ontario, Canada lost power.

Before the even more recent blackouts associated with Hurricane Isabelle that many of you have experienced, the August 14th blackout was the eighth area-wide loss of power in seven years. It differed from the prior seven blackouts in one respect – the cause was not seen as an act of God. Herewith the recent record:

1996 – A falling tree branch in Idaho led to a failure cascade, blacking out 18 states.
1997 – An ice storm in Quebec downed transmission lines and blacked out much of New England.
June 1998 – A tornado downed a Wisconsin power line leading to rolling brownouts east of Mississippi.
2000 – Low water and a failed nuclear plant caused a power crisis in California with a month of brownouts and rolling blackouts. This nearly bankrupted California.
1999-2002 – Three separate ice storms caused large area blackouts in Oklahoma.

2003 – A thirty-one year old coal plant in Ohio tripped. Lines overloaded as power moved from further away, voltage dropped, dramatically reducing the capacity of transmission lines and 50 million people lost power.

A review of electric generation history

For electricity's first 100 years, the optimal way to produce and deliver power was with large, remote central stations feeding long wires; this formed a deep, central generation bias. Initially all power came from two central technologies - - hydro and coal fired steam plants. Hydroelectric plants were inherently remote and early coal plants were noisy and dirty - - not good neighbors. Also coal plants required skilled operators, making them inappropriate for smaller users. For 80 years, power from remote plants – linked to the user by an ever-growing set of wires – enjoyed cost advantages over local power. Nuclear power technology, commercialized in the 1960's, was also seen as inherently remote by everyone but Admiral Rickover and the US Navy.

Everyone assumed that central generation was and would always be technically and economically optimal. Many laws and regulations reinforced this assumption. If all generation is central, then all power must flow through wires, which seemed to be a natural monopoly. Laws enshrined a monopoly approach, with good results. The country was rapidly electrified and power prices feel from $4.00/kWh in 1900 to 5.8 cents /kWh in 1968. The electric age celebrated its 88th birthday. Technology was changing but local power technologies were blocked.

The monopoly approach created an incredibly strong power industry with deeply vested interests in all power flowing through their wires, and once central technologies matured, progress stopped. Between 1969 and 1984 power prices rose 65%. After 1959, delivered average efficiency never improved beyond 33%. But things changed. People came to hate the ugly fifth column of transmission lines. We learned more about the bad side effects of burning fossil fuel and as population grew, electricity demand grew with it. Fossil fuel imports also grew, unbalancing the budget. Then 9/11 terrorist attacks focused attention on infrastructure vulnerability.

These issues must inform the discussions about preventing blackouts. Fortunately, we have the technology to simultaneously address all problems if we change the central generation paradigm:

1. Build local power
2. Build smaller
3. Recycle waste energy.

Distributed generation comes of age

Technical progress has provided many local power answers. It employs proven central generation technologies and fuels but is located next to electric and thermal loads. DG power goes directly to users, bypassing transmission, and DG plants recycle normally wasted heat, saving fuel and pollution. Local generation options are technically ripe, environmentally superior, and at least twice as efficient as average central generation. In fact, much of the technical progress has occurred as a result of government supported research.

But do not limit focus to sexy new technologies like micro turbines, solar photovoltaic or fuel cells. There are many proven local power technologies, matched to all medium to large electric loads.

Economics of scale have been reversed by the microcomputer. Small steam turbines, able to extract power from local energy waste were available in 1950 but required operators, making most onsite generation less economic than central power. Today, microcomputer controls enable steam turbines to operate unattended and produce economic local power.

Modern gas turbines are clean and compact, unobtrusive neighbors. Two 5MW gas turbines now generate power at the steam plant serving the White House, the DOE and the EPA, and they are more than twice as efficient as central plants because they recycle wasted heat. Their power needs no transmission wires. It stays home.

The most efficient gas turbine yet built is a 50 megawatts LM6000GE, matched to middle sized industrial complexes or large universities. The next best turbine in the world is 4 megawatt solar mercury turbine, perfect for hospitals and small industry.

An even better local power opportunity burns no new fuel. The US flares waste gas, vents waste process heat and fails to harness steam pressure drop that could support 45 to 90 gigawatts of local, fuel-free, pollution free, wire-free power - - over 10% of US load. Only 1 to 2 gigawatts of this waste energy is currently recycled. The needed technology is available, proven, and less expensive than central plants & wires.

The US is out of transmission capacity and electric peak load is projected to grow by 43% over 20 years - - 300 gigawatts. Line losses have grown from 5% in 1960 to 9% in 2002 and exceed 20% on peak. If we stay with the central generation paradigm, we must build 375 GW of large new plants to accommodate peak line loses. By contrast, 300 GW of local power will meet peak load with no new wires and no added line loses. And, because local plants can recycle waste heat, we will burn only half the fuel.

The technology is here today but it is the outmoded laws, regulations and the vested interests in central power that keep deployment at bay.

As I have said, the optimal approach is to:

1. Build local power
2. Build smaller
3. Recycle waste energy.

<u>How can Congress find solutions?</u>

This Congress faces a seemingly unpleasant task. The power industry begs help to build more wires - - $100 billion of new wires and an improved grid. They ask for new federal eminent domain rights to enable new wires to slash through forests and backyards. This will raise prices, annoy voters, and largely fail to address system vulnerability or to mitigate power system related problems.

There is a better approach:

1. Demand and use the right metric in all discussions. What is the delivered cost of power? Stop focusing on capital cost and the cost per kWh at the generator - - count the line costs and line losses and extra capital for peak loads. Recognize the locational value of power.
2. Remove regulatory barriers to local power. Instead of new federal eminent domain for transmission wires, overturn the 50 state bans on private wires. Give distributed generation operators the right to bypass the wires monopoly and deliver their power across the street, just as federal laws allow private gas pipes. Few private pipes are built and few private wires will be built, but lifting bans on private wires will transform the power industry, ending the ability of monopolies to block local power with excessive line charges. Couple this right with standardized interconnection access, the right to backup power and an environmental regulatory framework that recognizes the environmental benefits of the combined production of power and heat (CHP).
3. Encourage and/or demand recycled power development. Pass a clean portfolio standard that requires a growing percentage of power from renewables and recycled energy. Give manufacturers a reason to recycle waste fuel, waste heat and pressure drop.
4. The work of the national laboratories has pushed the frontier of technology but with efforts often conducted in isolation of broader national needs. There is a need to assess and refute the still widespread belief that distributed generation can not be safely integrated into the electric distribution system at reasonable costs. Every effort should be made to showcase and highlight the many existing commercial technologies that DOE and others have had a role in developing which can safely and cost effectively integrate DG into the grid.

This is a short summary of an analysis showing that the optimal way to meet future electric load growth is with distributed generation - - using proven technology DG. I have attached a more comprehensive analysis in the form of a paper entitled “Preventing Blackouts”.

In closing, let me reiterate how to prevent more blackouts while saving money and reducing pollution:

1. Build local power
2. Build smaller
3. Recycle waste energy.

Biography of Thomas R. Casten

Chairman and CEO Private Power

Thomas R. Casten has spent over 25 years developing and operating combined heat and power plants as a way to save money, increase efficiency and lower emissions. A leading advocate of clean and efficient power production, Mr. Casten is the founding Chairman and CEO of Private Power LLC, an independent power company in Oak Brook, IL, which focuses on developing power plants that utilize waste heat and waste fuel. In 1986 he founded Trigen Energy Corporation and served as its President and CEO until 1999. Trigen's mission reflects that of its founder: to produce electricity, heat, and cooling with one-half the fossil fuel and one-half the pollution of conventional generation.

Mr. Casten has served as President of the International District Energy Association and has received the Norman R. Taylor Award for distinguished achievement and contributions to the industry. He currently serves on the board of the American Council for an Energy-Efficient Economy (ACEEE), the board of the Center for Inquiry, and the Fuel Cell Energy Board. He is the Chairman of the World Alliance for Decentralized Energy (WADE), an alliance of national and regional combined heat and power associations, wind, photovoltaic and biomass organizations and various foundations and government agencies seeking to mitigate climate change by increasing the fossil efficiency of heat and power generation. Tom's book, "*Turning Off The Heat,*" published by Prometheus Press in 1998, explains how the US can save money and pollution.

Preventing Blackouts

Whether 'tis Nobler to Spend or to Save: That is the Question

Thomas R. Casten, September 8, 2003

New York City, Early Evening, August 14, 2003

Preventing Blackouts

On August 14th, around 2:00 PM, a 31-year-old, 650 megawatt Ohio power station failed. Transmission controllers struggled to route power from remote plants, overloading transmission lines. At 4:06, a 1200-megawatt transmission line melted, starting a failure cascade. Lacking local generation, system operators could not maintain voltage and five nuclear plants tripped, forcing power to flow from more remote plants and overloaded regional lines. By 4:16 PM, the northeastern US and Ontario, Canada lost power.

This was the eighth major North American outage in seven years

This was the eighth major North American outage in seven years, not counting five localized blackouts in New York City and Chicago. These area wide failures began in 1996 with a blackout of 18 western states, followed by a 1997 ice storm in Quebec that knocked out much of New England, a 1998 tornado that crippled midwestern power systems, California system failure in 2000, three ice storms in Oklahoma and the August 2003 blackout. Pundits spread blame widely and call for massive investment in wires, while ignoring the fundamental flaw – **excessive reliance on central generation of electricity**.

Power system problems are deeper than repeated transmission failures. Average US generating plants are old (average age 35 years), wasteful (33% delivered efficiency) and dirty (50 times the pollution of the best new distributed generation). Centralized generation, besides requiring ugly, highly visible transmission lines, does not recycle its own byproduct heat or extract fuel-free power from industrial waste heat and waste energy. This leaves two starkly contrasting ways to address blackouts:

- Spend billions on new wires. This will not completely eliminate blackouts and will exacerbate other problems.
- Save money by encouraging distributed generation. This will greatly reduce system vulnerability and deliver a host of other benefits.

Distributed generation (DG) has come of age. It employs proven central generation technologies and fuels but is located next to electric and thermal loads. DG power goes directly to users, bypassing transmission, and DG plants recycle normally wasted heat, saving fuel and pollution. Local generation options are technically ripe, environmentally superior, and at least twice as efficient as average central generation.

Unfortunately, laws and regulations block distributed generation. The industry and its regulators are caught in an overloaded, wire-entangled web that blocks innovation.

The Wiring of America

Central generation – long considered optimal – is an outgrowth of early generating technologies. Hydroelectric plants were inherently remote and early coal plants were noisy and dirty - - not good neighbors. And coal plants required skilled operators, making them inappropriate for smaller users. For 80 years, power from remote plants – linked to the user by an ever-growing set of wires – enjoyed cost advantages over local power.

By contrast, transportation required small engines that did not need skilled operators. Coal was tried for automobiles (the Stanley Steamer), but soon displaced by oil fired piston engines. For the first six decades of the 20th century, power technology evolved along two separate paths – coal fired steam turbines for electricity and oil fueled piston engines for transportation.

Over time, engine-driven power plants became cheaper to build, but required more expensive fuel and were only economic for backup or remote electric generation. Coal fired steam power remained a better value for electricity into the 1960 period.

Aircraft needs spurred another power generation technology, the combustion turbine. Pioneered near the end of WWII, early combustion turbines lacked efficiency but produced more power per pound than engines – critical to aircraft. Technology marched on. By the early 1980's, combined cycle gas turbine plants had become more efficient than the best steam power plants. To fill the gap left by environmental pressure on coal plants, turbine manufacturers developed turbines suitable for stationary power generation.

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By 1980, local gas turbine generation cost less to install and operate, required less net fuel and produced fewer net emissions that the best possible remote gas turbine generation and associated wires. Turbines are available from sub-megawatt to two hundred megawatt, appropriate for local loads; the plants are all automated, clean and quiet. Generating power locally avoids capital for transmission lines and eliminates transmission losses. Local power plants, unlike remote generation plants, can recycle byproduct heat, reducing net fuel use and cost. The power industry embraced turbine technology, but clung to central generation, missing opportunities to save money and pollution with distributed gas turbine generation.

Many other trends of the past thirty years also make distributed generation attractive. Turbine and piston engine power plant electric efficiency continues to increase. Transmission system losses of remotely generated power have increased from 5% to 9%, due to congestion. Computer controls enable unattended local generation based on waste gas and waste fuel. The most efficient generation technology ever invented, backpressure steam turbines, were historically limited by operator needs. With computer controls, these devices can economically extract power from waste heat, waste fuel, and steam pressure drop in virtually every large commercial and industrial facility. The US currently vents or flares heat, low-grade byproduct fuel and steam pressure drop that could support 45 to 90 gigawatts of backpressure turbine generation capacity - 6 to 13% of current US peak load.[1]

Even coal-fired local power now beats the costs of power delivered from remote coal plants. Advances in fluid bed boilers enable on-site production of heat and power with coal, biomass and other solid fuels in environmentally friendly plants. The limestone beds chemically bond with sulfur as calcium sulfate and limit combustion temperatures, reducing NOx formation. These clean coal plants, located near users, recycle heat to achieve 2.5 times the efficiency of remote coal plants.

Given all of these advances, an optimal power system would generate most power near load, using existing wires to shuttle excess power. Because electricity flows to the nearest connected users, regardless of the sales contract, locally generated power bypasses transmission lines.

Which brings us back to those long protected, overburdened, vulnerable, and *failing* wires that connect remote central plants to customers. Although the power industry finds itself waist deep in the big muddy, it clings to central generation. **Every stakeholder pays.** Power

[1] Thomas R. Casten and Martin J. Collins, *Recycled Energy: An Untapped Resource*, April 19, 2002.

prices shot up by 65% from 1968 to 84, needless environmental damage continues, many major industry players have declared bankruptcy or are close, banks are saddled with billions of non-performing loans to new central plants and blackouts have become a way of life.

Regulations and Industry Responses

Competition cleanses, discarding firms that cling to yesterday's technology. But the electric industry has long been sheltered from competition. *The electric industry's guiding signals have, since 1900, come from regulation rather than from markets*. All "deregulation" to date has left intact universal bans on private electric wires and many rules that penalize local power generation and protect the incumbent firms from cleansing competition. History sheds light on how and why utilities and regulators have enshrined central generation and largely continued to oppose local power generation.

Electricity, commercialized in 1880, is arguably the greatest invention of all time. But early developers faced a big problem, finding money for wires to transport electricity to users who didn't think they needed it. To manage the risk, developers asked city councils for five-year exclusive franchises.

Electricity is arguably the greatest invention of all time.

Thousands of small electric companies sprang up; by 1900, there were 130 in Chicago alone. Greedy alderman sold votes to extend franchises. Samuel Insull conceived of (and got) an Illinois state granted monopoly in perpetuity. State monopolies spread.

States established regulatory commissions to approve capital investments and set rates that assured utilities fair returns on capital. Under rate-based regulation, investments in efficiency improvements increase the rate base, but all savings go to customers. This approach does not allow utilities to profit from increasing efficiency. This misalignment of interests eventually caused industry stagnation, but in the early years, utilities chased efficiency to compete with candles, oil lamps, muscle power and self-generation.

Banks cheerfully loaned money to monopoly-protected utilities fueling a race to grow and acquire other systems. Power entrepreneurs borrowed huge sums to gain control over vast areas of the country. In 1929, the bubble burst; demand for electricity sagged, and over leveraged trusts could not pay debt service. Utility bankruptcies deepened the Great Depression. Congress's response – the Public Utility Holding Company Act (PUHCA) – prevented utility amalgamation and assigned federal watchdogs to oversee finances. PUHCA blocked profit growth via acquisition or financial engineering. Profit-seeking utilities had two options: (1) sell more power and (2) invest more capital in the rate base.

Both strategies favored central generation over local power. Utilities sponsored research in electric appliances, motors and other novel uses of electricity that increased sales and provided significant public benefits. But they also fought local generation with every available means.

Electric distribution companies have an understandable bias against generation that bypasses their wires and cuts potential profits. Utility monopolies long made it "Job One" to preserve the monopoly. The electric industry sponsored "Ready Kilowatt" campaigns to win industry love and skillfully coached (and paid) governments at every level to block distributed generation.

For eight decades, central generation was the optimal technology. The regulatory approach delivered nationwide electrification and real prices fell by 98%. Electrification not only improved standard of living, but also played a strong role in positive social change.

Then, beginning in the late 1960's problems arose. Central generation ceased to be optimal, but the industry ignored local power innovations. Which brings us back to stakeholder costs.

The Good Times End

By 1960, as competition withered away, utilities began pursuing questionable strategies. With no way to recycle byproduct heat, fuel efficiency never moved beyond 33%. Utilities and their regulators rushed to convert many coal-fired power plants to oil, just in time for the OPEC embargo in 1973. Many utilities committed to build massive central plants that required up to ten years to construct, far beyond safe planning horizons. When rising prices induced conservation, electric load growth flattened and left the industry with massive overcapacity.

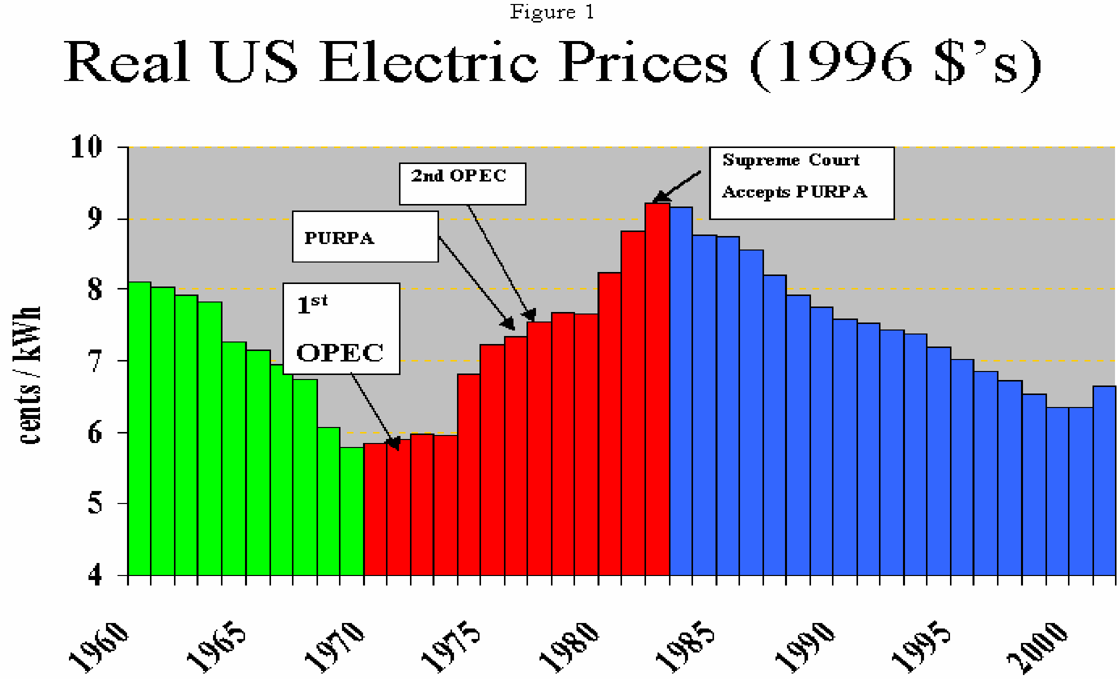
Then came nuclear. The utility industry committed vast sums, underestimating complexity and safety concerns. Some nukes were built near budget, but others broke the bank. Cost overruns of 300% to 500% were common. Long Island Lighting spent 19 years and $5 billion building Shoreham, only to have New York Governor Cuomo close the plant before it generated any power.

Figure 1 shows the rising real prices of US electricity after 1968.[2] From 1970 to 1984, real electric prices rose 65%.

Regulatory responses nearly got it right, flirting with local generation. The 1978 Public Utility Regulatory Policy Act or PURPA sought to improve efficiency by exempting plants that recycled some heat from Federal Power Act regulations and required utilities to buy power from these plants at avoided costs. Utilities fought PURPA to the Supreme Court, losing in 1984. But subsequent changes removed the pressure to build plants near users, and nascent DG was again driven back.

Next came Three Mile Island. State commissions, fed up with nuclear cost overruns and rising prices, overturned the tacit regulatory compact. They challenged the prudence of utility investments in nuclear plants, claiming mismanagement. Historically friendly regulators ordered CEO's to remove billions of dollars from rate base and reduce electric prices. Utility shareholders took a bath.

Figure 1



[2] Prices given in 1996 dollars as reported at www.eia.doe.gov.

The two changes did stop electric price inflation; prices dropped to 1969 levels by 2000. But utility managements went into shock. They curtailed in-system investments, but still needed to put massive cash flow to work. Smarting from independent power producers' (IPP's) "poaching" of their generation under PURPA, many utilities funded unregulated subsidiaries to "poach" generation in other territories. Never questioning the central generation mantra, utility subsidiaries began a disastrous race to build remote gas turbine plants, ignoring this strategy's vulnerability to rising gas prices. In thirteen months following May, 2001, the eleven largest merchant power plant builders destroyed over $200 billion of market capitalization. ENRON, NRG, and PSE&G and Mirant have since declared bankruptcy while, Dynegy, CMS and Mission struggle to pay creditors. Industry players that embraced gas-fired remote merchant plant development have seen their credit ratings lowered to junk status. These mistakes have already cost a dozen utility CEO's their jobs, pounded utility shareholders and caused enormous bank losses.

The costs to all stakeholders from the central generation worldview extend to other societal problems.

Major transmission failures did not start immediately. Spare transmission capacity, built in the days of compliant regulation, absorbed load growth until 1996, when a falling tree set off an 18 state blackout throughout the west. By then, load growth had made the non-growing T&D system vulnerable to extreme weather (ice storms, tornados, hurricanes and drought induced hydro electric shortages), human error, and terrorists.

As costs and environmental concerns mounted, States began to experiment with partial deregulation, but never eased protection of wires, leaving utilities free to continue fighting DG by charging excessive backup rates and denying access to customers. Commissions allowed generators to sell to retail customers, but then set postage stamp transmission rates, charging the same to move power across the street or across Texas. DG power, which only moves across the street, was left to pay identical transmission rates to power moving hundreds of miles through expensive transmission wires. Wholesale power prices give little recognition to the locational value of generation.

Environmental regulations also suppress distributed generation. The 1976 Clean Air Act and subsequent amendments penalize efficiency. Almost all emission permits are granted based on fuel input, with no relationship to useful energy output. All new generation plants are required to install "best available control technology," while existing plants retain 'grandfather" rights to emit at historic levels. These grandfather rights give economic immortality to old central stations and block innovation, and thus bear some responsibility for system failures.

The costs to all stakeholders from the central generation worldview extend to other societal problems. The balance of payments suffers from needless fuel imports. The US demands for fossil fuel begat military adventures. Inefficient generation raises power costs, hurts industrial competitiveness and makes electric generation the major source of greenhouse gas emissions, threatening entire ecosystems.

An Exception Disproves the Rule

NIPSCO encouraged local power at the steel mills they serve in northern Indiana. Parent NiSource formed an unregulated subsidiary in 1994 that invested over $300 million in 460 megawatts of distributed power. Primary Energy built five projects that recycle waste heat and normally flared blast furnace gas. All of the power is consumed at the steel mills, easing transmission congestion and supporting local voltage.

The steel mills collectively save over $100 million per year by producing power with waste energy. These distributed generation projects produce no incremental emissions and displace the emissions of a medium sized coal fired station, 24/7. They are the environmental equivalent of roughly 2,500 megawatts of new solar collectors, which would only operate 20% of the time, on average.

These projects have not hurt NIPSCO, on balance. Yes, the utility sells less electricity to the mills, but steel production has risen, requiring more shifts and pumping up the local economy, increasing other electric sales. There is no reason why similar projects cannot be built to the benefit of all stakeholders in every other electric territory.

Ending central generation bias will upset vested interests and require a great deal of political effort, but the rewards for this leadership will be immense

Whether 'tis Nobler to Spend or to Save; That is the Question

There are two distinct paths to avoid blackouts. Spend $50 to $100 billion on new and upgraded transmission lines or save money by removing barriers to distributed generation.

The first path will raise electric rates by 10 to 15% and will exacerbate other problems. The second path will cost taxpayers nothing and mitigate other problems.

To follow the second path, governments must:

- Allow anyone to sell backup power
- Enact standard and fair interconnect rules
- Void laws that ban third parties from selling power to their hosts.
- Give every power plant identical emission allowances per unit of useful energy.
- Recognize the locational value of generation.
- Most importantly, allow private wires to be built across public streets.

These changes will transform the $390 billion US heat and power business into a dynamic marketplace of competing technologies and allow distributed generation's competitive advantages to prevail. Utilities and IPP's will build new DG capacity to serve expected electric load growth and reduce transmission congestion.

Ending central generation bias will upset vested interests and require a great deal of political effort, but the rewards for this leadership will be immense – lower power prices, reduced pollution, reduced greenhouse gas emissions, and a vastly less vulnerable national power system.

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Thomas R. Casten has spent 25 years developing decentralized heat and power as founding President and CEO of Trigen Energy Corporation and its predecessors and currently as founding Chairman and CEO of Private Power LLC, an Illinois based firm specializing in recycling energy. Tom currently serves are Chairman of the World Alliance for Decentralized Energy (WADE), an alliance of national and regional combined heat and power associations, wind, photovoltaic and biomass organizations and various foundations and government agencies seeking to mitigate climate change by increasing the fossil efficiency of heat and power generation.

Tom's book, "Turning Off the Heat," published by Prometheus Press in 1998, explains how the US can save money and pollution.

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